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Re: Operations and Maintenance Alternatives for Removing Trees From Dams

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I. General Operations and Maintenance Considerations

A. Purpose

The purpose of this technical note is to outline and discuss the alternatives for maintenance of dam embankments containing trees and heavy brush. This Technical Note contains general recommendations and provides guidance on evaluating the interrelationships between tree types, tree locations, soil types, and depth of normal pool. It is recognized that the responsible engineer may weigh additional factors in arriving at a final plan for tree removal or treatment. In some cases the final plan may require total removal of all tree roots.

The guidelines presented here assume that the dam in question has been properly designed and constructed prior to tree invasion. It is anticipated that this document will serve as a working tool and help promote consistency (1) when evaluating several damsites simultaneously, (2) when two or more individuals are involved in maintenance inspections and recommendations, and (3) over extended periods of time and changes in personnel.

B. Problem Discussion

SCS O&M Handbooks and project agreements have always required that dams and emergency spillways be kept free of trees and brush by regular mowing or treatment. It is also recognized that maintenance has not always been performed when needed. If yearly O&M inspections indicate the existence of trees and brush, our O&M recommendations require that trees and brush be removed from the dam embankments immediately.

1. Roots

a. Piping - Where trees have been allowed to grow to some size, cutting the trees may create a problem. The decay and deterioration of larger roots after the tree has been cut and killed can eventually result in open channels in the fill, creating possible seepage paths. This condition could be extremely serious in soils with a high potential for piping. The greatest concern usually involves trees on the downstream side of the earthfill dam where seepage exits occur.

b. Drain infiltration - Tree roots commonly plug drain lines used for subsurface land drainage, and they can and do plug drain outlets for dams.

2. Scour

Scour damage can be induced by trees located in the exit of emergency spillways and on the slopes of dams. The scour damage occurs during overtopping of the dam or when the emergency spillway flows. The damage is caused by water turbulence around an obstruction to the flow. Trees providing obstructions along the top of the dam, on the downstream slopes or in the exit channel of the earth spillway can induce serious damage by progressive scour eorsion. This kind of failure has been observed and documented in numerous cases.

During high water levels scour damages can occur on the upstream slope of the dam. The scour damage is caused when waves are wind driven up the slope and the sheet of water recedes at a faster rate causing scour below the tree obstruction.

3. Vegetation

Trees reduce the available moisture in the soil due to interception and transpiration. They also reduce light available to desirable grass and legume cover and compete for space. It is clear that the establishment and maintenance of good grass and legume vegetative covers require the control of trees and other woody growth on dams.

C. Considerations for Tree Removal

1. The best alternative is to prevent the growth of trees by regular mowing of the dam. If a low maintenance cover is established, then cutting new trees every 2-3 years would be necessary.

2. Once trees have been allowed to establish, the recommendation is to remove them in all cases. Remaining stumps should be chemically treated to prevent sprouting.

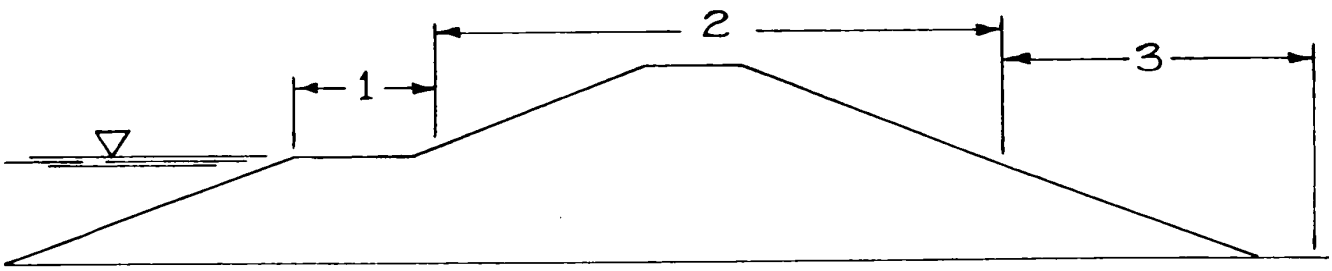
3. The removal of stumps and root mass will be required where the potential for problems from seepage, slope stability or drain clogging exists.

4. Where scouring potential exists from flowing water, the remaining stumps should be cut at least 6" below ground and filled over with compacted earth.

II. Factors Affecting Recommendations for Stump and Root Mass Removal

A. Tree Location Zones

These zones are general areas of an earthfill dam that can have significant differences with regard to alternatives for tree removal. Zone limits are variable with each individual structure. Recommendations in Table A are keyed to these zones.



1. Waterline - Potential problems include slope damage from tree blowdown, visual masking of the structure that may hinder clear observation of a potential problem, tree root interception of spillway conduits, treetop interference with hydraulic performance of principal spillways and wave action scour due to obstructions.

2. Frontslope, Crown and Backslope - Potential problems include seepage in root zone through the narrow top section at high water periods, damage from uprooting during blowdown, visual masking of covered areas, scour potential during overtopping due to obstructions, and seepage paths along roots that intercept the phreatic line from the backslope.

3. Toe of Dam - Potential problems include the development of a seepage path along roots that intercept drainage outlets or phreatic surfaces, root clogging of drainage systems, visual masking of the toe area where seepage is most likely, loss of the protective blanket if trees are uprooted by a storm event and scour from obstructions during overtopping. (This zone needs to extend at least 20 feet beyond the toe of slope.)

B. Types of Impoundments and Embankments

1. Impoundment

As the depth of permanently impounded water becomes a greater percent of dam height, the potential problems associated with existing trees may increase. This may require more careful anc extensive removal and repair. Although this factor is not recognized in Table A, it must be a consideration in determining the extent of the problem and potential hazard in each case.

2. Embankment

The nature of the materials and their distribution in the embankment are the factors considered.

a. Dispersed clay shells or dispersed materials in dams with thin protective shell.

b. Embankment with chimney drain or pervious downstream shell.

c. Homogeneous or zoned embankment with outside shell soils of low PI, with moderate to high piping potential.

d. Homogeneous or zoned embankment with soils of moderate-high PI, low permeability, low piping potential.

C. Types, Sizes, and Distribution of Trees

1. Types of Trees (Root Systems)

A distinction is made between trees that have a deep taproot as opposed to the more common spreading root system. Special notes are used in the tables to address the root growth of water-loving trees such as willow.

a. Long taproot - Generally, pines and other coniferous trees.

b. Spreading root systems - Deciduous trees such as willows, cottonwood, sycamore, sweetgum, red maple, silver maple, water oak, willow oak, pin oak, Nuttall's oak, Southern red oak, elm, yellow poplar, hickory, etc.

2. Sizes of Trees

Eight inches diameter at breast height is used as the tree size where root system may start to be significant.

a. DBH $< 8"$ = Average diameter at breast height is less than 8".

b. DBH $\geq 8"$ = Average diameter at breast height is 8" or greater.

3. Distribution of Trees

Tree distribution will determine whether the root system can be considered isolated and independent or continuous and joined with other systems over a significant area.

a. Isolated or scattered trees = light cover. Light cover is defined as three trees per 400 square feet with a DBH $< 8"$ or two trees per 400 square feet with a DBH $\geq 8"$ or more.

b. Clumps or continuous tree growth = heavy cover. Heavy cover is defined as more than three trees per 400 square feet with a DBH $< 8"$ or more than two trees per 400 square feet with a DBH $\geq 8"$ or more.

III. Criteria and Recommendations for Stump and Root Mass Removal

A. Definition of Treatment Methods

Consideration of the factors previously listed was used to develop the appropriate treatment methods for stump and root mass removal on embankments. General recommendations are summarized in Table A.

Definitions of each of the treatment methods listed in this table is as follows:

1. Cut and Kill Stump

Trees should be cut approximately six inches below the ground surface to eliminate the hazard of any surface obstruction.

An approved silvicide should be applied to the stump surface, as recommended by the manufacturer, prior to backfilling and reseeding.

2. Cut and Grub Stumps and Root Mass to Specified Depth Uniformly

In the area specified, a uniform cut will be made with appropriate equipment. The underlying root mass that remains will be disturbed as little as possible by using sharp cutting tools. Exposed tap roots will be treated with an appropriate silvicide to prevent reemergence.

3. Cut and Grub Stumps and Root Mass to Depth and Diameter of Removal Dictated by Type and Size of Tree (See Tables)

For taprooted trees, the removal of this mass should create a roughly parabolic shaped hole with a depth and diameter at the surface as specified in the tables. For spreading root trees, the depth of removal shown in the tables should be uniform over the diameter area specified in the tables.

4. Complete Removal of Stump and Root System

It is anticipated that this treatment will be unusual and must be judged on an individual basis. Generally this would be an impractical solution and may, in some cases, be detrimental to the structure. Some of the complications are as follows: (1) area of disturbance, (2) depth and slopes of excavation, (3) procedures for effective backfilling of the excavation, (4) timing and duration of the removal operation.

5. Partial Removal of Stumps and Root Systems and the Addition of a Filter (See backfill method 3, page 6.)

This treatment may be the most positive solution when there is concern for piping but treatment number 4 (complete removal) is not feasible.

B. Types of Backfill and Methods of Backfilling After Removal of Stumps and Root Mass

1. Selection of Soil Materials for Backfill

The selection of soil for the backfilling of treated areas should be based primarily on the permeability characteristics of the backfill with respect to the surrounding embankment.

Generally backfill materials in Zones 1 and 2 of the embankment should be of similar permeability to the adjacent embankment. In embankments of known dispersive clays care must be taken to find nondispersed clay borrow material or treat dispersed borrow material with hydrated lime.

For backfill in Zones 3 and 4, if the materials in the embankment are permeable shell type materials, it is important that borrow material be at least as permeable and preferably more permeable than the adjacent fill material. At the same time, in critical locations, the borrow soils should satisfy filter design criteria to prevent any possible piping.

2. Method of Placement and Backfill

Where stump and root mass removal is to a uniform depth over an accessible area, backfill should be placed in lifts no thicker than 6" and compacted at about optimum moisture by at least two passes of the tracks of the earth moving equipment.

Where stump and root mass removal is in confined areas, backfill should be compacted with hand directed power tampers. Backfill should be placed at a minimum of 90 percent maximum dry density (ASTM D-698A) and approximately optimum moisture. Lift thickness should be 4-6".

3. Special Treatment

Where extensive root mass removal is necessary and seepage is either evident or probable, the use of a filter may be appropriate. Filter material gradations must be selected to prevent piping or movement of embankment materials but allow seepage and safe exit of water. The filter may be added in conjunction with partial removal of extensive root systems.

C. General Recommendations for Tree Removal

Table A on page 8 contains general recommendations for tree removal.

TABLE A

GENERAL RECOMMENDATIONS FOR TREE REMOVAL 1/

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TREE LOCATION ZONE	TREE TYPE A (TAP ROOT) DBH < 8" LIGHT COVER	TREE TYPE A (TAP ROOT) DBH < 8" HEAVY COVER	TREE TYPE A (TAP ROOT) DBH ≥ 8" LIGHT COVER	TREE TYPE A (TAP ROOT) DBH ≥ 8" HEAVY COVER	TREE TYPE B (SPREADING ROOTS) DBH < 8" LIGHT COVER	TREE TYPE B (SPREADING ROOTS) DBH < 8" HEAVY COVER	TREE TYPE B (SPREADING ROOTS) DBH ≥ 8" LIGHT COVER	TREE TYPE B (SPREADING ROOTS) DBH ≥ 8" HEAVY COVER
1 1/	Cut and kill stumps.	Cut and kill stumps.	Cut and kill stumps.	Cut and kill stumps.	Cut and kill stumps.	Cut and kill stumps.	Cut and kill stumps.	Cut and kill stumps.
2 4/	Cut and kill stumps. 2/	Cut and grub stumps and root mass to 18" depth uniformly.	Cut and grub stumps and root mass to 24" depth in 1/2 crown width diameter area.	Cut and grub stumps and root mass to 24" depth uniformly.	Cut and kill stumps 2/	Cut and grub stumps and root mass to 12" depth uniformly.	Cut and grub stumps and root mass to 18" depth in crown width diameter area.	Cut and grub stump and root mass to 18" depth uniformly.
3 7/	Cut and kill stumps.	Cut and grub stumps and root mass to 18" depth uniformly.	Cut and grub stumps and root mass to 24" depth in 1/2 crown width diameter area. 3/	Cut and grub stumps and root mass uniformly to 18" depth.	Cut and kill stumps. 5/	Cut and grub stumps and root mass to 12" depth uniformly. 5/	Cut and grub stumps and root mass to 18" depth in crown width diameter area. 3/ 5/	Cut and grub stumps and root mass uniformly to 12" depth. 6/

1/ Tree growth smaller than 2" DBH will be removed by spraying, injection or cutting and stump killing. Trees and shrubs planted for shoreline protection in Zone 1 shall be maintained at heights < 4 feet.

2/ In embankment type (a) dispersed soil--cut stumps 12 inches below surface and backfill with compacted soil.

3/ In embankment type (d) earthfill with low piping potential--cut and kill stumps.

4/ In riprapped or heavy rockfill sections grubbing is not required.

5/ For water-loving trees such as willows, remove stump and root mass in twice the crown width area.

6/ For water-loving trees such as willows, remove stumps and root mass to 18" depth uniformly.

7/ Individual large trees in this zone may need the special treatment as described in Section 3.